Introduction to MBTA Red Line Capacity

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DEFINITIONS OF MBTA SERVICE AND CAPACITY

When an agency provides mass transit service, capacity means the ability to move many people from many entry points to many destinations in shared vehicles. Usually we talk about maximum capacity, not minimum. Capacity is a measure of how many people a transit system can serve. But how many people?

A train can be full, at "crush capacity," but be stalled in a tunnel. It will have capacity to provide temporary storage for many people, but if the train is not moving its service capacity is zero. The challenge for rapid transit is to move as many people as possible. When the Red Line is moving, it is providing service.

The MBTA has adopted a Service Delivery Policy to "ensure that the MBTA provides quality transit services that meet the needs of the riding public..." [2010 Update, page 1] This policy is designed to fulfill the mission of the MBTA :

> "*The MBTA is a dedicated world-class transit system built upon consumer service excellence, accessibility, reliability, state-of-the-art technology, and a diverse workforce that reflects our commitment to the communities we serve."*

The service objectives (p. 3-4) are :

Accessibility … Service offers good geographical distribution and convenience

Reliability … Service should run as scheduled – to be on-time and dependable

Safety … Service should offer both the reality and the feeling of safety among patrons

Comfort … Transit travel should "provide a pleasant and comfortable riding environment"

Cost-Effectiveness … "Services should be tailored to target markets in a financially sound and cost-effective manner"

The Service Policy takes these objectives and translates them into Service Standards or guidelines (p. 4)

Accessibility …..... Area coverage, daily times of service and frequency of service
Reliability …..... Schedule adherence – being on-time
Safety and Comfort... Train loadings
Cost effectiveness …. Net cost per customer.

These standards say nothing about how rapid the rapid transit service should be. Trains could be moving at 5 miles an hour … or 50. The policy itself mentions the word "capacity" only four times, all on page 14 in relation to seating and standing loading capacities of buses or trains. No mention is made of capacity as movement. The word "capacity" is not defined in the Glossary on page 22.

DISCOVERING CAPACITY IN THE SERVICE DELIVERY POLICY

However, two Service Standards can be combined – frequency of service and train load. The result is the discovery of moving capacity. In theory, the more people are loaded into each train and the more frequently the trains arrive, the higher the capacity of the service. This concept of capacity does not say anything about speed, but it can indicate how many people the Red Line could be capable of serving.

The MBTA sets the loading capacity of a six-car Red Line train at about 1000 people. If trains arrive every four minutes, that is equivalent to fifteen trains an hour. The moving capacity is fifteen times 1,000 or 15,000 people each hour. The MBTA Service Delivery Policy for the Red Line means that scheduled headways (separations between trains) of four minutes will mean the capacity of one track is 15,000 riders an hour.

Simply stated, if we know the headway and the loading capacity of each train, we know the moving capacity. In 1926, the Boston Elevated Company ran trains into Harvard Station on two-minute headways … or 30 trains an hour. If the company could have run six-car trains with 1,000-person loading, that would mean a track capacity of 30,000 riders an hour. Shorter headways mean the transit agency can move more people.

WAYS TO INCREASE CAPACITY

Other ways to increase capacity are to have longer trains and longer cars, ... or to take all the seats out of a car. The MBTA tried this last idea with their unsuccessful Big Red cars on the Red Line.

Another way to increase capacity is to squeeze more people into each car. The Japanese are famous for using "pushers." These are athletic young men who physically push people into the trains, "compressing them like sardines." Many western nations see such a policy as demeaning, and the MBTA can cite its policy on safety and comfort, with passengers complaining about riding at "crush capacity." The Policy cites limits on how fully the trains should be loaded.

TRAIN BUNCHING HAS CAPACITY IMPLICATIONS

Finally, another way to increase capacity is to plan for and achieve even spacing of trains on the Red Line. This strategy avoids bunching of trains. Measurements I have made at Park Street show wide variations in headways -- from less than 2 minutes, to as long as 17 minutes. When trains have short headways they often travel half-empty or less. Last December I was on a rush hour train entering Alewife Station, and my train was one of four waiting to be released from the Alewife terminal. With only two storage tracks at the station, two of the trains had to wait on the approach tracks until the station tracks were cleared out.

More distressing to many riders are those occasions of delayed trains with very long headways. Most commonly one late train is leading a bunching of other trains following closely behind. A Cambridge business leader and a City Councillor both report anguish at waiting for four trains at Kendall Station before being able to get on a train. Such reports suggest a system seemingly over-capacity, without room for any new riders.

The combination of transit service with a mix of short and long headways is very common world-wide. Buses and trains can get bunched together creating long waiting delays for passengers, crowded conditions on some trains, and other trains that are half-empty or less. I have seen Red Line trains at rush hour that were virtually empty at Park Street. Empty seats and unused space for standees all represent lost capacity in the

service. Thus we can identify bunching as the primary cause for loss of capacity in existing Red Line service. A significant amount of system capacity is not accessible because of uneven train spacing. The solution is to run the trains on time, evenly spaced, so that available capacity is increased, using existing trains and personnel.

The details of increasing capacity in the Red Line (including bunching) will be discussed in a later paper. Calculations of capacity in this paper will assume an even spacing of trains.

JAPANESE TRANSIT EXPERIENCE

The Japanese have realized they made a mistake in using pushers to increase train loading. Over the past decade, the Japanese rail system has removed pushers from train platforms. One issue involved safety – a woman was reportedly crushed to death on a train. Another is the technical realization that people were taking so much time to get on and off trains that the whole system became seriously delayed. Japanese transit was losing capacity, not gaining it. Their solution is to remove the pushers and replace them with gentlemanly attendants who urge passengers to step back and not overload trains. Loudspeakers deliver the same message and stress the need for the train to leave soon. Today the Japanese run *almost* fully loaded trains with two-minute headways and evenly-spaced trains. The Japanese are moving more than three and a half times as many rail-cars down a single track as the MBTA achieves.

HOW THE MBTA ESTIMATES TRAIN LOADINGS AND CAPACITY

The MBTA estimates the practical loading capacity of Red Line cars as 167 passengers in each car. [2010 Policy Update, page 27] A six-car train will carry a total load of 1,002 passengers. The scheduled headway in the peak hour is 4.5 minutes for the mainline tracks between Alewife and JFK. These headways are the same as having 13.33 trains in the peak hour. The scheduled capacity becomes 13,367 passengers per hour.

An improved method would be to count trains that are not scheduled but are run as directed. MBTA management can insert extra trains into long gaps that may open up in service. In reality, it is better to operate those extra trains as part of regular service. In my Red Line counts of two years ago, the average measured headways were in the range of 4 minutes plus 15 to 20 seconds. Measured capacity becomes 13,850 passengers per hour.

ABSOLUTE MAXIMUM TRAIN LOADING : CRUSH CAPACITY

The car storage capacity of 167 riders per car is slightly arbitrary and is based on the ratio of standing to seated passengers. Two standing riders for every seat represents a loading capacity of 167 riders per car. Four standing riders per seat is called the “crush capacity” of the car and is 277 passengers per car. This 277 figure represents the physical limit of the car – it is impossible to get another person on.

The Japanese experiments were based first on trying to push the bounds of crush capacity into super-crush conditions, and then realizing that they had gone beyond the ideal and were actually reducing moving capacity. The MBTA figure of 167 riders per car represents an awareness of the hazards of overloading trains, and the need to recognize the comfort and safety interests of the passengers.

HOW DO RIDERSHIP COUNTS COMPARE WITH RED LINE CAPACITIES?

Red Line Riders often complain of a lack of adequate capacity. They express concerns about delays, crowding, and transit congestion. The common perception is of a Red Line “at capacity” or “over capacity.” One MBTA official claimed publicly that the Red Line is today at crush capacity.

The claims of insufficient capacity are not supported by a comparison of ridership counts and capacity. Passenger counts of inbound arrivals at Kendall Square in the morning peak hour is 9,524. [Notice of Project Change, Kendall Square Amendment 10, by Cambridge Redevelopment Authority, April 2015. p. 2-45]. With a Red Line capacity calculated above of 13,850 passenger per hour, the capacity exceeds the ridership by 4,326.

The Red Line is neither over-capacity nor at-capacity. It is clearly operating under-capacity.

THE VOLUME-TO-CAPACITY RATIO

The Volume-to-Capacity or V/C ratio is in common usage among traffic engineers to represent traffic counts or demand compared to highway volume. If the amount of traffic is only half the capacity, we would say the V/C is 0.50. It is like the glass of water that is either half full or half empty. Similarly a V/C ratio of 0.75 means the intersection is ¾ full or 25% empty. We could also say that there is 25% of the capacity that is not being utilized.

On the Red Line, the *morning peak* ridership of 9,524 compares to a capacity of 13,850. The V/C ratio is 0.69. Only 69% of the capacity is being utilized and 31 % is not being used. During the *afternoon* peak hour, the ridership leaving outbound Kendall Square is 8,821, and the corresponding V/C ratio in the PM is 0.64.

CONCLUSIONS ON UNUSED RED LINE CAPACITY

I conclude that the Red Line is using about 2/3 of its capacity. It is not using 1/3 of its capacity. Stated somewhat differently, if it were possible to fully utilize all unused capacity, the ridership on the Red Line could increase by half. This 50% increase in possible ridership could be achieved using existing trains and employees. The most effective strategy to retrieve this lost capacity is to run the trains on time.

NEXT STEPS.

The next introductory paper on Red Line service issues will consider the effects of bunching on the Red Line. The focus will be on the wide range in headways – with some trains loaded to crush capacity, while other trains can run almost empty. Proposals will be offered to run the trains on time and significantly reduce the wide spread in headways from today's average variations of 100 seconds … and seek to limit such variations to an average of ten seconds. Such a new policy would compare with 7.6 second average variation on subway trains in Japan. Formulas to relate capacity to bunching will be developed. The implications for passenger daily, including unexpected large delays will also be considered. Cost-benefit implications will be assessed.

Subsequent topics to be discussed will be :

….. An assessment of national and international experience with reducing headways to no more than two minutes, including 1926 Boston experience with two-minute headways and 90 second headways during World War II.

….. The capacity benefits of adding new cars, operators and power capacity to permit reduced headways, with cost implications.

….. Possible reuse of many series 1500 to 1700 cars to give extended service for at least another decade and to expand the Red Line fleet to achieve shorter headways and more capacity after new Red Line cars arrive..

….. Proposals to make the Boston public transit service into the best transit system in North America.

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